

Application No. 09/783,996
Reply to Office Action of June 30, 2003

IN THE CLAIMS

Please amend the claims as follows:

Claim 1 (Original): A position control apparatus of an optical system comprising an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated on the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a holding means,

an actuator for moving the holding means in the focus direction perpendicularly intersecting the storage surface of the optical storage medium, and

a control circuit for controlling the actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed.

Claim 2 (Original): A position control apparatus of an optical system as set forth in claim 1, wherein

said control circuit controls said actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

controls said actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

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Claim 3 (Original): A position control apparatus of an optical system as set forth in claim 1, wherein

the numerical aperture of said optical system is greater than 1 and not greater than 3, and

the region where said near-field is formed is in a contactless state with said optical system and said optical storage medium, and said distance is in the range no more than 500 nm.

Claim 4 (Original): A position control apparatus of an optical system comprising an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated on the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a holding means,

a first actuator for moving the holding means in a focus direction perpendicularly intersecting the storage surface of the optical storage medium,

a second actuator for moving the holding means in a radial direction of the optical storage medium,

a first control circuit for controlling the first actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed, and

a second control circuit for controlling the second actuator on the basis of the reflected light from the optical storage medium.

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Claim 5 (Original): A position control apparatus of an optical system as set forth in claim 4, wherein

said first control circuit controls said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

said second control circuit controls said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 6 (Original): A position control apparatus of an optical system as set forth in claim 4, further comprising a moving means for moving an optical head carrying at least said optical system, said first actuator, and said second actuator in the radial direction of said optical storage medium.

Claim 7 (Original): A position control apparatus of an optical system as set forth in claim 4, wherein said second control circuit controls said second actuator on the basis of the reflected light of said optical storage medium, so that tracking control is performed based on at least one of a guiding channel existing on said optical storage medium, an emboss pit and a storage mark.

Claim 8 (Original): A position control apparatus of an optical system as set forth in claim 4, wherein said second control circuit generates a tracking error signal using any method among a push-pull method, 3-spot method, differential push-pull method, and phase difference method and controls said second actuator on the basis of the tracking error signal.

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Claim 9 (Original): A position control apparatus of an optical system as set forth in claim 4, wherein

the numerical aperture of said optical system is not less than 1, and

the region where said near-field is formed is in a contactless state with said optical system and said optical storage medium, and said distance is in the range no more than 500 nm.

Claim 10 (Original): A position control apparatus of an optical system comprising an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated on the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a holding means,

a first actuator for moving the holding means in the focus direction perpendicularly intersecting the storage surface of the optical storage medium,

a second actuator for moving the holding means in the direction perpendicularly intersecting the signal storage direction on the optical storage medium,

a first control circuit for controlling the first actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium is within the region where the near-field is formed, and

a second control circuit for controlling the second actuator on the basis of the reflected light from the optical storage medium,

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a first moving means for moving an optical head carrying at least the optical system, the first actuator, and the second actuator in the direction perpendicularly intersecting the signal storage direction on the optical storage medium, and

a second moving means for moving an optical head carrying at least the optical system, the first actuator, and the second actuator in the signal storage direction on the optical storage medium.

Claim 11 (Original): A position control apparatus of an optical system as set forth in claim 10, wherein

said first control circuit controls said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

said second control circuit controls said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 12 (Original): A position control apparatus of an optical system as set forth in claim 10, wherein said second control circuit controls said second actuator on the basis of the reflected light of said optical storage medium, so that tracking control is performed based on at least one of a guiding channel existing on said optical storage medium, an emboss pit and a storage mark.

Claim 13 (Original): A position control apparatus of an optical system as set forth in claim 12, wherein said second control circuit generates a tracking error signal using any method among a push-pull method, 3-spot method, differential push-pull method, and phase difference method and controls said second actuator on the basis of the tracking error signal.

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Claim 14 (Original): A position control apparatus of an optical system as set forth in claim 10, wherein

the numerical aperture of said optical system is not less than 1, and

the region where said near-field is formed is in a contactless state with said optical system and said optical storage medium, and said distance is in the range no more than 500 nm.

Claim 15 (Original): A position control method of an optical system for controlling a distance with an optical system which forms a near-field with an optical storage medium and irradiates a converging light beam to the optical storage medium and the optical storage medium by moving the optical system in the focus direction perpendicularly intersecting the storage surface of the optical storage medium, said method comprising a step of

controlling an actuator for moving a holding means, fixing an objective lens converging the light beam to be irradiated to the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium, in the focus direction on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium is within the region where the near-field is formed.

Claim 16 (Original): A position control method of an optical system as set forth in claim 15, further comprising steps of

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controlling said actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

controlling said actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 17 (Original): A position control method of an optical system as set forth in claim 15, wherein

the numerical aperture of the optical system is greater than 1 and not greater than 3, and

the region where said near-field is formed is in a contactless state with the optical system and said optical storage medium, and said distance is in the range no more than 500 nm.

Claim 18 (Original): A position control method of an optical system for controlling the distance between an optical system which forms a near-field with an optical storage medium and irradiates a converging light beam to the optical storage medium and the optical storage medium by moving the optical system in a focus direction perpendicularly intersecting the storage surface of the optical storage medium, said method comprising the steps of

controlling a first actuator for moving a holding means, fixing an objective lens converging the light beam to be irradiated to the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium, move in the focus direction on the basis of electrostatic capacitance formed by the electrode

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and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed and

controlling a second actuator and moving the holding means in the radial direction of the optical storage medium on the basis of a reflected light from the optical storage medium.

Claim 19 (Original): A position control method of an optical system as set forth in claim 18, further comprising steps of

controlling said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

controlling said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 20 (Original): A position control method of an optical system for controlling the distance between an optical system which forms a near-field with an optical storage medium and irradiates a converging light beam to the optical storage medium and the optical storage medium by moving the optical system in a focus direction perpendicularly intersecting the storage surface of the optical storage medium, said method comprising the steps of

controlling a first actuator for moving a holding means, fixing an objective lens converging the light beam to be irradiated to the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium, move in the focus direction on the basis of electrostatic capacitance formed by the electrode

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and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed,

moving an optical head carrying at least the optical system, the first actuator, and a second actuator in a direction perpendicularly intersecting the signal storage direction on the optical storage medium, and

moving an optical head carrying at least the optical system, the first actuator, and the second actuator in the signal storage direction on the optical storage medium.

Claim 21 (Original): A position control method of an optical system as set forth in claim 20, further comprising steps of

controlling said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

controlling said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 22 (Original): A storage and reproduction apparatus comprising
a light source,

an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated to the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a holding means,

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an actuator for moving the holding means in a focus direction perpendicularly intersecting the storage surface of the optical storage medium,

a control circuit for controlling the actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed,

a motor for rotating the optical storage medium when storing information and reproducing information,

an intensity modulation circuit for modulating the intensity of the light from the light source according to the information to be stored when storing information, and

an information detection circuit for detecting the recorded information from the reflected light reflected by the optical storage medium when reproducing information.

Claim 23 (Original): A storage and reproduction apparatus as set forth in claim 22, wherein

said control circuit controls said actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

controls said actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 24 (Original): A storage and reproduction apparatus comprising a light source, an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated to the optical storage medium and a solid immersion lens with

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an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a holding means,

a first actuator for moving the holding means in the focus direction perpendicularly intersecting the storage surface of the optical storage medium,

a second actuator for moving the holding means in the radial direction of the optical storage medium,

a first control circuit for controlling the first actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed,

a second control circuit for controlling the second actuator on the basis of the reflected light from the optical storage medium,

a motor for rotating the optical storage medium when storing information and reproducing information,

an intensity modulation circuit for modulating the intensity of the light from the light source according to the information to be stored when storing information, and

an information detection circuit for detecting the stored information from the reflected light reflected by the optical storage medium when reproducing information.

Claim 25 (Original): A storage and reproduction apparatus as set forth in claim 24, wherein

said first control circuit controls said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

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said second control circuit controls said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 26 (Original): A storage and reproduction apparatus as set forth in claim 24, further comprising a moving means for moving an optical head carrying at least said optical system, said first actuator, and said second actuator in the radial direction of said optical storage medium.

Claim 27 (Original): A storage and reproduction apparatus comprising a light source, an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated to the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a holding means,

a first actuator for moving the holding means in a focus direction perpendicularly intersecting the storage surface of the optical storage medium,

a second actuator for moving the holding means in a direction perpendicularly intersecting the signal storage direction on the optical storage medium,

a first control circuit for controlling the first actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed,

a second control circuit for controlling the second actuator on the basis of the reflected light from the optical storage medium,

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a first moving means for moving an optical head carrying at least the optical system, the first actuator, and the second actuator in the direction perpendicularly intersecting the signal storage direction on the optical storage medium,

a second moving means for moving an optical head carrying at least the optical system, the first actuator, and the second actuator in the signal storage direction on the optical storage medium,

an intensity modulation circuit for modulating the intensity of the light from the light source according to the information to be stored when storing information, and

an information detection circuit for detecting the stored information from the reflected light reflected by the optical storage medium when reproducing information.

Claim 28 (Original): A storage and reproduction apparatus as set forth in claim 27, wherein

said first control circuit controls said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

said second control circuit controls said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 29 (New): A position control apparatus of an optical system comprising

an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated on the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light

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beam converged by the objective lens to the optical storage medium are fixed by a lens holder,

an actuator for moving the lens holder in the focus direction perpendicularly intersecting the storage surface of the optical storage medium, and

a control circuit for controlling the actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed.

Claim 30 (New): A position control apparatus of an optical system as set forth in claim 29, wherein

said control circuit controls said actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

controls said actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

Claim 31 (New): A position control apparatus of an optical system as set forth in claim 29, wherein

the numerical aperture of said optical system is greater than 1 and not greater than 3, and

the region where said near-field is formed is in a contactless state with said optical system and said optical storage medium, and said distance is in the range no more than 500 nm.

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Claim 32 (New): A position control apparatus of an optical system comprising

an optical system forming a near-field with an optical storage medium and irradiating a converging light beam to the optical storage medium, wherein an objective lens converging the light beam to be irradiated on the optical storage medium and a solid immersion lens with an electrode formed on a surface facing the optical storage medium and irradiating the light beam converged by the objective lens to the optical storage medium are fixed by a lens holder,

a first actuator for moving the lens holder in a focus direction perpendicularly intersecting the storage surface of the optical storage medium,

a second actuator for moving the lens holder in a radial direction of the optical storage medium,

a first control circuit for controlling the first actuator on the basis of electrostatic capacitance formed by the electrode and the optical storage medium and of a reflected light from the optical storage medium so that the distance between the solid immersion lens and the optical storage medium becomes within the region where the near-field is formed, and

a second control circuit for controlling the second actuator on the basis of the reflected light from the optical storage medium.

Claim 33 (New): A position control apparatus of an optical system as set forth in claim 32, wherein

said first control circuit controls said first actuator on the basis of said electrostatic capacitance until the distance between said solid immersion lens and said optical storage medium becomes a target value, and

said second control circuit controls said second actuator on the basis of the reflecting light from said optical storage medium after the target value is reached.

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Claim 34 (New): A position control apparatus of an optical system as set forth in claim 32, further comprising a moving mechanism configured to move an optical head carrying at least said optical system, said first actuator, and said second actuator in the radial direction of said optical storage medium.

Claim 35 (New): A position control apparatus of an optical system as set forth in claim 32, wherein said second control circuit controls said second actuator on the basis of the reflected light of said optical storage medium, so that tracking control is performed based on at least one of a guiding channel existing on said optical storage medium, an emboss pit and a storage mark.

Claim 36 (New): A position control apparatus of an optical system as set forth in claim 32, wherein said second control circuit generates a tracking error signal using any method among a push-pull method, 3-spot method, differential push-pull method, and phase difference method and controls said second actuator on the basis of the tracking error signal.

Claim 37 (New): A position control apparatus of an optical system as set forth in claim 32, wherein

the numerical aperture of said optical system is not less than 1, and

the region where said near-field is formed is in a contactless state with said optical system and said optical storage medium, and said distance is in the range no more than 500 nm.